Evaluating the Effect of Outfit on Personality Perception in Virtual Characters

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Abstract: Designing virtual characters that are capable of reflecting a sense of personality is a key goal in research and applications in virtual reality and computer graphics. More and more research efforts are dedicated to investigating approaches to construct a diverse, equitable, and inclusive metaverse by infusing expressive personalities and styles into virtual avatars. While most previous work focused on exploring variations in virtual characters’ dynamic behaviors, characters’ visual appearance plays a crucial role in affecting their perceived personalities. This paper presents a series of experiments evaluating the effect of virtual characters’ outfits on their perceived personality. Based on the related psychology research conducted in the real world, we determined a set of outfit factors likely to reflect personality in virtual characters: color, design, and type. As a framework for our study, we used the “Big Five” personality model for evaluating personality traits. To test our hypothesis, we conducted three perceptual experiments to evaluate the outfit parameters’ contributions to the characters’ personality. In our first experiment, we studied the color factor by varying color hue, saturation, and value; in the second experiment, we evaluated the impact of different neckline, waistline, and sleeve designs; and in our third experiment, we examined the personality perception of five outfit types: professional, casual, fashionable, outdoor, and indoor. Significant results offer guidance to avatar designers on how to create virtual characters with specific personality profiles. We further conducted a verification test to extend the application of our findings to animated virtual characters in augmented reality (AR) and virtual reality (VR) settings. Results confirmed that our findings can be broadly applied to both static and animated virtual characters in VR and AR environments that are commonly used in games, entertainment, and social networking scenarios.

Keywords: virtual agents; virtual reality; augmented reality; perception; personality evaluation; nonverbal expression

1. Introduction

One important focus in VR and AR research is to develop effective virtual characters for applications like computer gaming, social interaction, virtual story systems, online education, etc. To represent real humans that exist in the physical world, avatars in digital environments must be able to convey personality, mood, and emotions [1–7]. Even though research remains active in the area of constructing computational frameworks for designing expressive virtual characters, most efforts have been dedicated to modalities like language, gestures, body motion, eye movement, and facial expression. Little is known about how virtual characters’ visual appearance, such as outfits, impacts their perceived personality. To bridge the gap in research, this work investigates the influence of outfits on virtual characters’ perceived personality, enabling avatars to be created effectively to represent authentic humans with desired personalities, which promotes a more diverse, expressive, and inclusive virtual demographic in digital realms like the metaverse.

An outfit demonstrates a wearer’s taste, mood [8], style [9], and social identity [10], and it plays a significant role in providing nonverbal cues [11] in communication. Both
Naumann et al. [12] and Fiore and DeLong [13] show that personality can be reliably inferred from peoples’ clothing, which is a key channel of information. This paper examines how outfits impact personality perception of avatars in the virtual realm. We draw our insights and stimuli design from previous psychological literature to carefully select three main factors in outfits and systematically evaluate the associations people make between outfit variations and personality traits for virtual characters through a series of perceptual experiments.

According to previous psychological work, aspects of an outfit, such as color tone, darkness [13], saturation [9], collar, neckline, waistline [13], skin-revealing design [11], practicality [11], and professionalism [8,10], all impact the personality traits perceived in real humans. Hence, we categorized three main outfit factors—**color**, **design**, and **type**—that likely influence a virtual character’s perceived personality. For each main factor, we further organized a set of outfit parameters as listed in Table 1 and performed a perceptual experiment to test our hypothesis. The hue, saturation, and value (HSV) model is used for the **color** factor, where red, green, and blue hues, high and low saturation, and light and dark values are examined in the first experiment. The **design** of neckline, waistline, and sleeves is evaluated in the second experiment. Five **types** of outfits, including professional, casual, fashionable, outdoor, and indoor, are studied in the third experiment. In order to create a sufficient variety of outfits on 3D virtual characters, social media applications Snapchat [14] and Bitmoji [15], which support expression at the demographic level, are utilized for experiment implementation. The factors and parameters in experiments have a good correspondence to common outfit options offered to virtual character designers and end users. We use the Big Five model [16–18], which has become a standard in psychology research, to evaluate the perception of virtual characters’ personalities. The model consists of five traits: extraversion, emotional stability (EMS), agreeableness, conscientiousness, and openness to experience, and adjectives associated with these traits are listed in Table 2.

The great majority of our experiments yielded significant results, and the detailed findings are reported in Section 4. These results suggest that people do reliably associate what virtual characters are wearing with their personality traits. Factor analysis on the three experiments’ ratings (in Section 4.4) indicates that outfit manipulation offers finer-grained influence on the five traits than motion adjustment in modalities such as gestures [1]. We propose outfit guidelines for creating avatars with specified personalities in Section 5.1. To generalize the applicability of our outfit findings and guidelines, we further conducted a verification test in an AR setting in the scenario of social communication and confirmed that significant outfit influence on perceived personality persists in the presence of animations.

To the best of our knowledge, this is the first work that systematically examines the impact of outfit parameters on virtual characters’ personalities. Previous work either conducted a study in the physical world, investigating the effect of one specific outfit feature on real humans’ one personality trait, or focused on studying the impact of virtual characters’ animations and behaviors, with characters’ appearance largely ignored. In comparison, our work involved comprehensive experiments on multiple outfit factors and parameters in the virtual realm and reported their impact on all five personality traits. We further integrated our outfit guidelines in a separate verification test and confirmed the broad applicability of our findings to both static and animated characters in AR and VR worlds. We summarize the fundamental contributions of our work as follows:

- We systematically designed and implemented a collection of experiments to better understand how outfits’ **color**, **design**, and **type** impact virtual characters’ perceived personality.
- We analyzed experimental results and summarized guidelines useful for designing avatars with specified personalities in the virtual realm.
- We discovered through factor analysis that outfit manipulation offers finer-grained impact on virtual characters’ perceived personality than motion adjustment.
- We verified the broad applicability of our findings for animated virtual characters in AR settings.
Table 1. Main outfit factors and parameters.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>hue</td>
<td>red, green, blue</td>
</tr>
<tr>
<td></td>
<td>saturation</td>
<td>high, low</td>
</tr>
<tr>
<td></td>
<td>value</td>
<td>regular, dark</td>
</tr>
<tr>
<td>Design</td>
<td>neckline</td>
<td>round neck, shirt collar, turtleneck, U-neck</td>
</tr>
<tr>
<td></td>
<td>waistline</td>
<td>high, regular</td>
</tr>
<tr>
<td></td>
<td>sleeves</td>
<td>long, short, sleeveless</td>
</tr>
<tr>
<td>Type</td>
<td>professional</td>
<td>suit, tuxedo, trench coat</td>
</tr>
<tr>
<td></td>
<td>casual</td>
<td>bomber, denim jacket, hoodie</td>
</tr>
<tr>
<td></td>
<td>fashionable</td>
<td>leather jacket, animal print coat, plush top</td>
</tr>
<tr>
<td></td>
<td>outdoor</td>
<td>down puffer, windbreaker, utility vest</td>
</tr>
<tr>
<td></td>
<td>indoor</td>
<td>cardigan, pajamas, shirt dress</td>
</tr>
</tbody>
</table>

Table 2. Descriptions associated with the Big Five traits. Bold adjectives are used in the Ten Item Personality Inventory (TIPI) Questionnaire.

<table>
<thead>
<tr>
<th>Trait</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraversion</td>
<td>assertive, active, extraverted, enthusiastic</td>
<td>passive, solitary, reserved, quiet</td>
</tr>
<tr>
<td>EMS</td>
<td>peaceful, confident, calm, emotionally stable</td>
<td>neurotic, vulnerable, anxious, easily upset</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>friendly, helpful, sympathetic, warm</td>
<td>malicious, selfish, critical, quarrelsome</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>controlled, careful, dependable, self-disciplined</td>
<td>inefficient, unreliable, disorganized, careless</td>
</tr>
<tr>
<td>Openness</td>
<td>creative, cultured, open to new experiences, complex</td>
<td>shallow, ignorant, conventional, uncreative</td>
</tr>
</tbody>
</table>

2. Related Work

Clothing is a form of nonverbal expression [19] and a systematic means of transmission of information about the wearer [20]. Many works in psychology have confirmed that information such as personality, emotion, and social identities can be reliably inferred from a person’s outfit. Ref. [12] examined the accuracy of zero-acquaintance personality impressions that observers made based on physical appearance and reported that accurate judgments can be made for a variety of personality traits from an outfit in the form of full-body photographs without personal interaction. According to [21], observers can make accurate personality inferences from personal possessions, including full outfit, that agreed with self-ratings made by the owners of the possessions. Ref. [22] studied the causal relationships between clothing styles and personality traits. Significant predictive relationships were found between outfit preference and agreeableness and neuroticism traits in the Big Five personality model in the authors’ follow-up work [8]. Ref. [23] confirmed that observers were able to perceive the social identity information presented in outfits selected by others to be representative of their personalities. Ref. [10] identified the links between clothing and self-concept and determined both public and private self-consciousness correlate to clothing attitudes and strategic use of clothing.

Based on findings from previous work, specific clothing features can be manipulated to elicit responses from observers. By using open-ended questions, Ref. [19] identified the collection of visual cues observers chose to use, e.g., fit, color, appropriateness, and overall assembly of an outfit, that leads to the impressions they make on others, including personality, behavioral traits, and social roles. Four clothing factors, i.e., exhibitionism, practicality, designer, and consciousness, are distilled in [11], and skin-revealing and fashionable designs, practical preferences, and occupational interests are investigated based
on personality traits. Ref. [13] evaluated clothing cues in personality perception using 25 sweaters of varying colors, body coverage, waist lengths, sleeve lengths, necklines, textures, and bulkiness features. Instead of using photos, actual garments were used, presenting physical features absent in pictorial stimuli. Eight outfits ranging from formal wear to evening wear to casual wear are presented by [8,22] to examine clothing preference based on the Big Five personality model. By extracting information such as outfit color, pattern, and silhouette from online celebrity images, ref. [9] trained a support vector machine (SVM) to accurately predict a person’s personality. Previous work [24] manipulated the outfits of a virtual health counselor to be perceived as more professional, trustworthy, reassuring, and more persuasive regarding medical decisions. However, due to the scarcity of virtual assets and thus the difficulty of covering a variety of virtual outfits, very little research has been done to systematically investigate the impact of clothing features on personality perception of avatars in the virtual realm.

In addition to visual appearance, a considerable body of work has focused on investigating the impact of verbal and nonverbal behaviors on perceived personality in the psychology and virtual agent communities. Linguistic variations [3,25–27] and nonverbal behaviors, including body shape [19,28], body posture [29–34], interaction distance [32,35,36], gaze [37], facial expression [19], gesture [1,2,38], hand motion [39], and rendering style [40], have been confirmed to have significant influence on personality perception. Further, the effects of detailed verbal and nonverbal features like linguistic verbosity, content polarity [3], gesture rate [2], motion fluency [31,41,42], velocity [31,34,42,43], tension [44], rhythm [41], posture expansiveness, facial hair and attractiveness [19], and body height, weight, and surface [19,28] have been systematically investigated. In comparison to clothing features, Ref. [12] found that both dynamic cues (e.g., facial expression, etc.) and static cues (e.g., clothing, etc.), offer valuable information into personality judgment. Additionally, outfit cues were rated by observers as more typical and carrying more personality information than the behavioral cues in [21], though not verified to be transferable to virtual characters. These findings motivate our evaluation work of the impact of outfit variations on the perception of a virtual character’s personality.

3. Stimuli Design and Implementation

While there has been little systematic research on outfits for virtual characters, variations in clothing have been shown to correlate to personality in the psychology literature (refer to Section 2 for more details). In this investigation, we selected three major factors in human perception, i.e., color, design, and type, from previous research. Our main hypothesis is that a virtual character’s perceived personality varies based on the variations of these three factors, e.g., the type of outfit a virtual character is wearing, the color of the outfit, and the design of the outfit’s neckline, waistline, and sleeves. To verify the hypothesis, we designed a collection of three experiments, each examining variations of one of the factors. Outfits were made for both male and female characters.

3.1. Stimuli Design
3.1.1. Outfit Color

Inspired by color features in [9,13], the HSV color model is used to examine the color factor instead of running random sampling on the RGB color palette. Thus, three fine-grained parameters, hue, saturation, and value, are explored. The color hues under investigation in our experiment are red, green, and blue. For each hue, we prepared one standard saturated color, its low-saturation light version, and another low-value, darker version. In order to better understand color, we further added three neutral colors—gray, white, and black—and examined their effects. To avoid any complications with the outfit design, simple T-shirts paired with gray pants are used in Experiment 1, with 12 varying top colors for male and female characters (illustrated in Figure 1).
3.1.2. Outfit Design

Skin-revealing features have been reported to correlate with perceived personality in psychology [11,13], and thus for the design factor, we focus on evaluating three design parameters: neckline, waistline, and sleeves. Selections for each parameter are listed in Table 1. By sampling the combinations of four necklines (round neck, turtleneck, U-neck, and shirt collar), two waistlines (high waist vs. regular waist), and three sleeve (long, short, and sleeveless) designs, we made 24 designs for two genders, totaling 48 characters, as illustrated in Figure 2. To avoid mixture with the color experiment, all tops in experiment 2 are white in color.

3.1.3. Outfit Type

According to clothing features used in [8,11,22], such as exhibitionism, professionalism, practicality, and designer, we included five representative types of outfits—professional, casual, fashionable, outdoor, and indoor—in Experiment 3 to examine their impact on a virtual
character’s perceived personality. For each outfit type, we selected three sets of full-body outfits for two genders to help mitigate any possible significant impact from a specific outfit selection and to better generalize the outfit type. We made 30 outfits (5 types × 3 variations × 2 genders). Detailed outfit configurations are listed in Table 3 and illustrated in Figure 3. During outfit selection, we tried to include similar color variation across types while still respecting the classic color association with a specific outfit, e.g., denim jackets are mostly seen in blue, trench coats are commonly in beige, and fashionable outfits often have more colorful patterns than other types. We regard such color association as intrinsic to the outfit type and did not make a deliberate effort to isolate them in Experiment 3.

Figure 3. Outfit variations of five types—Professional, Casual, Fashionable, Outdoor, and Indoor for two genders in Experiment 3.

Table 3. Full-body outfit configurations in Experiment 3 for five types, corresponding to the illustration in Figure 3.

<table>
<thead>
<tr>
<th>Type</th>
<th>Top</th>
<th>Bottom</th>
<th>Footwear</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_1$</td>
<td>blue suit</td>
<td>brown skirt</td>
<td>dark Mary Jane</td>
</tr>
<tr>
<td>$P_2$</td>
<td>black tuxedo</td>
<td>gray pants</td>
<td>black oxford</td>
</tr>
<tr>
<td>$P_3$</td>
<td>beige trench coat</td>
<td>gray pants</td>
<td>brown Chelsea</td>
</tr>
<tr>
<td>$C_1$</td>
<td>brown bomber</td>
<td>light jeans, rolled cuff</td>
<td>taupe loafer</td>
</tr>
<tr>
<td>$C_2$</td>
<td>denim jacket</td>
<td>dark jeans</td>
<td>blue flip flop</td>
</tr>
<tr>
<td>$C_3$</td>
<td>yellow pullover hoodie</td>
<td>tan cargo pants</td>
<td>olive loafer</td>
</tr>
<tr>
<td>$F_1$</td>
<td>black leather jacket</td>
<td>zebra-print skirt/</td>
<td>black high boots</td>
</tr>
<tr>
<td></td>
<td></td>
<td>floral-print shorts</td>
<td></td>
</tr>
<tr>
<td>$F_2$</td>
<td>cheetah-print fur coat</td>
<td>black leggings</td>
<td>combat boots</td>
</tr>
<tr>
<td>$F_3$</td>
<td>green knitwear/plush top</td>
<td>art print wide-leg</td>
<td>green high heel</td>
</tr>
<tr>
<td>$O_1$</td>
<td>yellow down puffer</td>
<td>beige cargo pants</td>
<td>gray sneaker</td>
</tr>
<tr>
<td>$O_2$</td>
<td>blue windbreaker</td>
<td>gray sweatpants</td>
<td>high-top sneaker</td>
</tr>
<tr>
<td>$O_3$</td>
<td>army utility vest</td>
<td>brown work pants</td>
<td>green Crocs</td>
</tr>
<tr>
<td>$I_1$</td>
<td>gray cardigan</td>
<td>lavender work pants</td>
<td>puffer slip-on</td>
</tr>
<tr>
<td>$I_2$</td>
<td>blue pajamas</td>
<td>N/A</td>
<td>plush slippers</td>
</tr>
<tr>
<td>$I_3$</td>
<td>white shirt dress</td>
<td>N/A</td>
<td>slide slippers</td>
</tr>
</tbody>
</table>
3.2. Implementation
3.2.1. Stimuli Implementation

To create virtual characters with all the aforementioned outfit variations, we used social media applications Bitmoji [15] and Snapchat [14], which support customizing 3D virtual characters with a large demographic diversity. The experimental outfits are configured in the Bitmoji app and rendered in the Snapchat app. First, we created male characters with medium weight and female characters with medium weight and medium breast body configuration in the Bitmoji app, on top of which, we customized different outfit selections. Although minor differences in outfit options for genders exist in the app, we tried to make similar outfits for gender counterparts. The created virtual characters are then posed in a natural standing posture with hands in pockets and rendered in a 3D scene with a solid gray background using the Snapchat app. The original rendered images are 894 × 1605 pixels in size, enclosing the character’s full body. To remove the software logo, the images were further cropped to 716 × 1200 pixels, in which the virtual character takes up the central 330 × 1080 region. We then masked the head part in gray blocks to avoid complications with the influence of facial features.

3.2.2. Experiment Organization

To recruit participants for the experiments, we posted online ads on Twitter and personal homepage websites. We had a brief screening to make sure that the participants are above 18 years old and had reasonable English understanding skills and color vision. The study was organized into three online experiments, which were made and delivered to participants through Google Forms. The first experiment presented 24 rendered images of characters in outfits with different color hues, saturation, and values (as shown in Figure 1), and was estimated to be able to be completed in about 30 min. The second experiment presented 48 rendered images of characters in outfits with design variations (Figure 2) and was estimated to be able to be completed in about 60 min. The third experiment presented 30 rendered images of characters in different types of outfits (Figure 3), and the estimated completion time was 40 min. Due to the large amount of stimuli, we acknowledged the potential fatigue among participants during the experiments and tried an experiment organization that could help reduce the fatigue effect. As the experiments were organized in three Google Forms, participants could choose to work on the experiments separately, which allows for rest time in between if needed. Participants completed the experiments through the web browsers on their own devices at their own pace, with the resolution of the rendered image fixed at 716 × 1200 pixels. For each experiment, participants viewed one virtual character at a time for all the outfits in random order and rated characters’ perceived Big Five personality traits using the Ten Item Personality Inventory (TIPI) questionnaire [45] on a 7-point Likert scale. Participants submitted their answers online and were compensated with Starbucks gift cards. We initially received responses from 39 participants, among which four incomplete answer forms were removed. Thus, the reported results were computed based on the ratings from the 35 participants (22 M, 13 F, ages ranged from 20~60 years old), with no further filtering applied. To be comparable and consistent with previous research in virtual characters’ personality perception [1,39], we considered results to be significant at the 95% level ($p < 0.05$). With balanced data, we conducted post hoc analyses using Tukey tests as in previous work [39].
4. Experiment Results

4.1. Experiment 1—Color

This study explored how variations in color *hue*, *saturation*, and *value* (listed in Table 1) influence a virtual character’s perceived personality traits. We used 24 outfits with 12 selected T-shirt colors for two genders in Experiment 1, as discussed in Section 3 and illustrated in Figure 1. Based on the previous outfit research in psychology [9], we hypothesized that:

- **H1**: Variations in *hue*, *saturation*, and *value* will significantly affect all personality traits perceived in virtual characters.

- **H2**: Warm hues will lead to high extraversion and agreeableness.

- **H3**: Reduced saturation will improve the perceived EMS, agreeableness, and conscientiousness.

- **H4**: Darker colors will be perceived as less extraverted and less open, but emotionally more stable and more conscientious.

Results

To evaluate the impact of different *hues*, we grouped the personality ratings of saturated red, denoted as $R_s$, low-saturation light red $R_l$, and low-value dark red $R_d$ in the red group; similarly, we included $\{G_s, G_l, G_d\}$ in the green group and $\{B_s, B_l, B_d\}$ in the blue group for the two genders (gender superscript omitted here). Across the hue and gender groups, we ran a two-way ANOVA test to analyze their effects and interactions. From the ratings, no significant differences were found between genders. Warm hues in the red group significantly increased a virtual character’s perceived extraversion and agreeableness but led to low emotional stability. In comparison, the blue group had the opposite effect as the warm hues. The findings confirm **H2**. However, the impact of hues is not significant on a character’s perceived conscientiousness and openness.

To examine the effect of *saturation*, we grouped saturated colors $R_s, G_s$, and $B_s$ in the high-saturation group and $R_l, G_l$, and $B_l$ in the low-saturation group for the two genders and ran the two-way ANOVA test across the saturation and gender groups. Results show that low-saturated colors are perceived as significantly less extraverted, less open, more emotionally stable, agreeable, and more conscientious, part of which confirms **H3**. No significant differences were found between genders.

To understand the impact of *value*, which corresponds to the darkness of the colors, we grouped low-value dark red $R_d$, dark green $G_d$, dark blue $B_d$, and black $N_b$ in the dark color group and compared their personality ratings with the regular group of $R_s, G_s, B_s$, and gray $N_g$. No significant gender differences were found in the personality ratings. The results confirmed **H4**. Darker outfits improved the virtual character’s perceived emotional stability and conscientiousness and made characters look more introverted and less open. However, darker colors did not lead to significantly different agreeableness. The resulting analysis in Experiment 1 shows that *hue, saturation*, and *value* impact different personality traits, but not all five, which disconfirms **H1**. Significant results are listed in Table 4, and detailed ratings are shown in Figure 4b.

When analyzing the 12 experimental colors individually, each color achieved high or low personality ratings based on their corresponding *hue, saturation*, and *value*, which was generally consistent with the findings above. Neutral colors in the experiment included white $N_w$, gray $N_g$, and black $N_b$. Colors in the neutral group all achieved significantly high and low ratings in specific personality traits: $N_b$ elicited the lowest extraversion, the lowest agreeableness, and the highest conscientiousness ratings; $N_w$ led to the highest EMS rating; and gray $N_g$ was perceived as the least extraverted and open. Detailed ratings for individual colors are shown in Figure 4a.
### Table 4. Significant results for the outfit color, design, and type experiments.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Traits</th>
<th>Effect</th>
<th>F-Test</th>
<th>Post hoc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Extraversion</td>
<td>Color</td>
<td>$F_{1,1166} = 45.743, p &lt; 0.001$</td>
<td>Most Extraverted: ${R_i, G_i}$. Least Extraverted: ${G_i, N_i, R_i}$</td>
</tr>
<tr>
<td></td>
<td>Hue</td>
<td>Hue</td>
<td>$F_{2,24} = 33.249, p &lt; 0.001$</td>
<td>Red $\geq$ (Green, Blue)</td>
</tr>
<tr>
<td></td>
<td>Saturation</td>
<td>Saturation</td>
<td>$F_{1,1166} = 68.809, p &lt; 0.001$</td>
<td>High Saturation $&gt;$ Low Saturation</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>Value</td>
<td>$F_{1,1166} = 49.282, p &lt; 0.001$</td>
<td>Regular $&gt;$ Dark</td>
</tr>
<tr>
<td>EMS</td>
<td>Color</td>
<td>Color</td>
<td>$F_{1,1166} = 23.497, p &lt; 0.001$</td>
<td>Most Stable: ${N_i, B_i, N_i}$. Least Stable: ${R_i, G_i}$</td>
</tr>
<tr>
<td></td>
<td>Hue</td>
<td>Hue</td>
<td>$F_{2,24} = 18.59, p &lt; 0.001$</td>
<td>Blue $&gt;$ Green $&gt;$ Red</td>
</tr>
<tr>
<td></td>
<td>Saturation</td>
<td>Saturation</td>
<td>$F_{1,1166} = 63.138, p &lt; 0.001$</td>
<td>Low Saturation $&gt;$ High Saturation</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>Value</td>
<td>$F_{1,1166} = 76.735, p &lt; 0.001$</td>
<td>Dark $&gt;$ Regular</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>Color</td>
<td>Color</td>
<td>$F_{1,1166} = 7.864, p &lt; 0.001$</td>
<td>Most Agreeable: ${R_i, R_i}$. Least Agreeable: ${N_i, N_i, R_i, B_i}$</td>
</tr>
<tr>
<td></td>
<td>Hue</td>
<td>Hue</td>
<td>$F_{2,24} = 23.305, p &lt; 0.001$</td>
<td>Red $\geq$ (Green, Blue)</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>Color</td>
<td>Color</td>
<td>$F_{1,1166} = 18.017, p &lt; 0.001$</td>
<td>Most Conscientious: ${G_i, B_i, N_i}$. Least Conscientious: ${G_i, R_i, N_i, R_i}$</td>
</tr>
<tr>
<td></td>
<td>Saturation</td>
<td>Saturation</td>
<td>$F_{1,1166} = 52.706, p &lt; 0.001$</td>
<td>Low Saturation $&gt;$ High Saturation</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>Value</td>
<td>$F_{1,1166} = 140.516, p &lt; 0.001$</td>
<td>Dark $&gt;$ Regular</td>
</tr>
<tr>
<td>Openness</td>
<td>Color</td>
<td>Color</td>
<td>$F_{1,1166} = 25.61, p &lt; 0.001$</td>
<td>Most Open: ${G_i, R_i, B_i}$. Least Open: ${G_i, N_i}$</td>
</tr>
<tr>
<td></td>
<td>Saturation</td>
<td>Saturation</td>
<td>$F_{1,1166} = 20.712, p &lt; 0.001$</td>
<td>High Saturation $&gt;$ Low Saturation</td>
</tr>
<tr>
<td></td>
<td>Value</td>
<td>Value</td>
<td>$F_{1,1166} = 38.79, p &lt; 0.001$</td>
<td>Regular $&gt;$ Dark</td>
</tr>
<tr>
<td>Design</td>
<td>Extraversion</td>
<td>Design</td>
<td>$F_{2,24} = 19.46, p &lt; 0.001$</td>
<td>Most Extraverted: ${UHN, RHN}$. Least Extraverted: ${RRL, SRL, RSS, TRL, TRS}$</td>
</tr>
<tr>
<td></td>
<td>Neckline</td>
<td>Neckline</td>
<td>$F_{2,24} = 28.732, p &lt; 0.001$</td>
<td>U-neck $&gt;$ (Shirt, Round) $&gt;$ Turtle</td>
</tr>
<tr>
<td></td>
<td>Waistline</td>
<td>Waistline</td>
<td>$F_{1,1166} = 121.556, p &lt; 0.001$</td>
<td>High Waist $&gt;$ Regular</td>
</tr>
<tr>
<td></td>
<td>Sleeves</td>
<td>Sleeves</td>
<td>$F_{2,24} = 457.137, p &lt; 0.001$</td>
<td>Sleeveless $&gt;$ Short $&gt;$ Long</td>
</tr>
<tr>
<td>EMS</td>
<td>Design</td>
<td>Design</td>
<td>$F_{2,24} = 12.928, p &lt; 0.001$</td>
<td>Most Stable: ${TRL, RSS, SRL, TRS}$. Least Stable: ${UHS, URN, UHL, UHN}$</td>
</tr>
<tr>
<td></td>
<td>Neckline</td>
<td>Neckline</td>
<td>$F_{2,24} = 53.261, p &lt; 0.001$</td>
<td>Round, Turtle $&gt;$ Shirt $&gt;$ U-neck</td>
</tr>
<tr>
<td></td>
<td>Waistline</td>
<td>Waistline</td>
<td>$F_{1,1166} = 24.705, p &lt; 0.001$</td>
<td>Regular $&gt;$ High Waist</td>
</tr>
<tr>
<td></td>
<td>Sleeves</td>
<td>Sleeves</td>
<td>$F_{2,24} = 33.806, p &lt; 0.001$</td>
<td>Long $&gt;$ Short $&gt;$ Sleeveless</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>Design</td>
<td>Design</td>
<td>$F_{2,24} = 15.934, p &lt; 0.001$</td>
<td>Most Agreeable: ${TRL, RSS, RRL, TRS}$. Least Agreeable: ${RHN, RHL, THN, SHN, SRN, RHS, UHN}$</td>
</tr>
<tr>
<td></td>
<td>Neckline</td>
<td>Neckline</td>
<td>$F_{2,24} = 4.77, p &lt; 0.003$</td>
<td>(Shirt, Round) $&gt;$ (Shirt, U-neck)</td>
</tr>
<tr>
<td></td>
<td>Waistline</td>
<td>Waistline</td>
<td>$F_{1,1166} = 166.242, p &lt; 0.001$</td>
<td>Regular $&gt;$ High Waist</td>
</tr>
<tr>
<td></td>
<td>Sleeves</td>
<td>Sleeves</td>
<td>$F_{2,24} = 32.416, p &lt; 0.001$</td>
<td>Short $&gt;$ Long $&gt;$ Sleeveless</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>Design</td>
<td>Design</td>
<td>$F_{2,24} = 17.367, p &lt; 0.001$</td>
<td>Most Conscientious: ${SRL, TRL, RSS, RRL, TRS, SRS}$. Least Conscientious: ${UHN, URN, UHL, THN, UHS, RHN}$</td>
</tr>
<tr>
<td></td>
<td>Neckline</td>
<td>Neckline</td>
<td>$F_{2,24} = 36.32, p &lt; 0.001$</td>
<td>Round, Shirt, Turtle $&gt;$ Shirt $&gt;$ U-neck</td>
</tr>
<tr>
<td></td>
<td>Waistline</td>
<td>Waistline</td>
<td>$F_{1,1166} = 109.165, p &lt; 0.001$</td>
<td>Regular $&gt;$ High Waist</td>
</tr>
<tr>
<td></td>
<td>Sleeves</td>
<td>Sleeves</td>
<td>$F_{2,24} = 66.607, p &lt; 0.001$</td>
<td>Long, Short $&gt;$ Sleeveless</td>
</tr>
<tr>
<td>Openness</td>
<td>Design</td>
<td>Design</td>
<td>$F_{2,24} = 26.356, p &lt; 0.001$</td>
<td>Most Open: ${UHN, SHN, UHS}$. Least Open: ${SRL, RRL, TRL}$</td>
</tr>
<tr>
<td></td>
<td>Neckline</td>
<td>Neckline</td>
<td>$F_{2,24} = 14.28, p &lt; 0.001$</td>
<td>Round, Shirt, Turtle $&gt;$ (Round, Shirt) $&gt;$ Turtle</td>
</tr>
<tr>
<td></td>
<td>Waistline</td>
<td>Waistline</td>
<td>$F_{1,1166} = 318.318, p &lt; 0.001$</td>
<td>High Waist $&gt;$ Regular</td>
</tr>
<tr>
<td></td>
<td>Sleeves</td>
<td>Sleeves</td>
<td>$F_{2,24} = 81.468, p &lt; 0.001$</td>
<td>Sleeveless $&gt;$ Short $&gt;$ Long</td>
</tr>
<tr>
<td>Type</td>
<td>Extraversion</td>
<td>Outfit</td>
<td>$F_{1,1166} = 42.504, p &lt; 0.001$</td>
<td>Most Extraverted: ${F_1, F_2, F_3}$. Least Extraverted: ${P_1, P_2, C_1}$</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Type</td>
<td>$F_{1,1166} = 92.13, p &lt; 0.01$</td>
<td>Fashionable $&gt;$ Outdoor $&gt;$ Casual $&gt;$ (Indoor, Professional)</td>
</tr>
<tr>
<td>EMs</td>
<td>Outfit</td>
<td>Outfit</td>
<td>$F_{1,1166} = 48.879, p &lt; 0.001$</td>
<td>Most Stable: ${P_i, P_i, C_i, O_i, C_i}$. Least Stable: ${F_1, F_2, F_3}$</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Type</td>
<td>$F_{1,1166} = 122.386, p &lt; 0.001$</td>
<td>(Professional, Casual, Outdoor) $&gt;$ Outdoor $&gt;$ Fashionable</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>Outfit</td>
<td>Outfit</td>
<td>$F_{1,1166} = 32.982, p &lt; 0.001$</td>
<td>Most Agreeable: ${C_1, I_1}$. Least Agreeable: ${F_1, F_2, F_3}$</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Type</td>
<td>$F_{1,1166} = 74.872, p &lt; 0.001$</td>
<td>(Casual, Outdoor, Indoor) $&gt;$ (Professional, Fashionable)</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>Outfit</td>
<td>Outfit</td>
<td>$F_{1,1166} = 54.41, p &lt; 0.001$</td>
<td>Most Conscientious: ${P_i, P_i, F_i}$. Least Conscientious: ${I_1}$</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Type</td>
<td>$F_{1,1166} = 153.897, p &lt; 0.001$</td>
<td>Professional $&gt;$ Outdoor $&gt;$ Casual $&gt;$ Fashionable $&gt;$ Indoor</td>
</tr>
<tr>
<td>Openness</td>
<td>Outfit</td>
<td>Outfit</td>
<td>$F_{1,1166} = 26.522, p &lt; 0.001$</td>
<td>Most Open: ${F_1, F_2}$. Least Open: ${P_1, P_2, I_3, I_1, C_1}$</td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td>Type</td>
<td>$F_{1,1166} = 60.636, p &lt; 0.001$</td>
<td>Fashionable $&gt;$ Outdoor $&gt;$ Casual $&gt;$ (Indoor, Professional)</td>
</tr>
</tbody>
</table>
4.2. Experiment 2—Design

Experiment 2 was designed to examine how outfits’ neckline, waistline, and sleeve variations (listed in Table 1) impact a virtual character’s personality perception. We configured 48 outfits, covering different collars, waistlines, and sleeve lengths, as discussed in Section 3 and illustrated in Figure 2. For identification purposes, we use three letters to denote each design, where the first letter indicates neckline (R, T, S, U for round, turtleneck, shirt collar, and U-neck, respectively), the second letter indicates the waistline (H for high waist and R for regular waist), and the last letter indicates sleeve length (L for long, S for short, and N for no sleeves), with the superscript remaining for gender. According to previous psychological literature, skin-revealing designs are perceived as more confident, aggressive [11], spontaneous, and energetic [13]. Hence, for virtual characters, we hypothesized that:

- **H5**: Variations in the neckline, waistline, and sleeves will impact all personality traits in a significant way.
- **H6**: Low U-necks, high waistlines, and sleeveless designs will be perceived as more extraverted and open.
- **H7**: Shirt collars will lead to the highest perceived conscientiousness and emotionally stable.

Results

To analyze the experiment results, we conducted a four-way ANOVA with neckline, waistline, sleeve, and gender as the factors. Significant results are listed in Table 4, and personality ratings and main effects are shown in Figure 5. For the neckline design, results show that a high turtleneck design achieved the highest EMS and agreeableness, but the lowest extraversion ratings; U-neck was perceived as the most extraverted, the most open, the least emotionally stable, and the least conscientious design. Having a shirt collar led to lower agreeableness ratings than a turtleneck and a round neck, possibly due to its formality. Although a shirt collar design is rated as more conscientious than a U-neck design, it is in the same conscientiousness level as a turtleneck and a round neck, which disconfirms H7. For the waistline design, results show that high-waist outfits were perceived as significantly more extraverted and open, but less stable, less agreeable, and less conscientious, compared to a regular waistline. For the design of sleeves, the results indicated that a sleeveless design significantly increased a virtual character’s perceived extraversion and openness, yet lowered a character’s perceived EMS, agreeableness, and conscientiousness. Further, an increase in sleeve length positively correlated to perceived...
EMS, but inversely correlated to extraversion and openness. However, long sleeves are not the most conscientious design, but rather were perceived as equally conscientious as short sleeves. Short sleeves are rated as significantly more agreeable than both long sleeve and sleeveless designs. Overall, the three design factors in the experiment—neckline, waistline, and sleeve—all led to significantly different personality ratings, which confirms H5. Skin-revealing designs (i.e., low U-neck, high waist, and no sleeves) all significantly improved a virtual character’s perceived extraversion and openness, which confirms H6.

Although no significant gender differences were found as a main effect, gender interacts with neckline and waistline designs on EMS, agreeableness, conscientiousness, and openness, as illustrated in Figure 6. Male characters wearing round, shirt, and turtleneck tops are perceived as more stable than female characters in the same neckline designs, but when in U-neck designs, they have a lower EMS level than female characters. Male characters are perceived as more agreeable than female characters while wearing shirt collar designs, but less agreeable in other neckline designs. For conscientiousness, male characters are more conscientious than female characters in round neck and shirt collar designs, but less conscientious wearing turtle and U-neck designs. Compared to female characters, male characters are more open, less stable, and less conscientious in high-waist designs but more stable, more conscientious, and less open in regular waistline designs.

Figure 5. Personality ratings for different necklines, waistlines, and sleeves in Experiment 2.

Figure 6. Gender * neckline and gender * waistline interaction effects in Experiment 2.

4.3. Experiment 3—Type

Thirty outfits of five types i.e., professional, casual, fashionable, outdoor, and indoor, were configured for both genders and examined in Experiment 3, with detailed specifications listed in Table 3 and illustrated in Figure 3. Based on the previous psychology literature [8,11,19], for the five outfit types, we hypothesized that:

- **H8**: Professional outfits will be perceived as the most conscientious type.
- **H9**: Casual outfits will lead to the highest agreeableness.
- **H10**: Fashionable outfits will be perceived as the most extraverted.
- **H11**: Outdoor clothing will receive the highest ratings for openness.
- **H12**: Indoor outfits will be perceived as the least open type.

Results

We ran a two-way ANOVA test to examine the effects of outfit type and gender. No significant gender influences were found from the personality ratings. The results verified the significant impact of outfit types on all personality traits. Among the five outfit types,
the professional outfits achieved the highest conscientiousness and the lowest extraversion, agreeableness, and openness levels, which confirms H8. Fashionable outfits were perceived as the least emotionally stable, the least agreeable, and the most extraverted, which confirms H10. Fashionable also received the highest ratings for openness, which were significantly higher than outdoor, thus disconfirming H11. Casual outfits were perceived as significantly more agreeable than professional and fashionable types but were in the same agreeableness level as indoor and outdoor outfits, which disconfirms H9. Indoor outfits achieved the least extraversion, the least conscientiousness, and the least openness levels, which confirms H12. Significant impacts and detailed rankings of the five outfit types on the Big Five personality traits are listed in Table 4.

Among the 15 outfit variations, the most extraverted outfits are all the fashionable outfits, F1, F2, F3, and the least extraverted ones are the professional suit P1, indoor pajamas I2, and casual hoodie C3. The most emotionally stable outfits are the professional tuxedo P2 and trench coat P3, the casual denim jacket C2 and hoodie C3, and the outdoor puffer O1, and the least emotionally stable ones are all three fashionable outfits. The most agreeable outfits are the casual hoodie C3 and indoor cardigan I1, and the least agreeable ones are the professional P1, P2 and all the fashionable outfits. The most conscientious outfits are all the professional outfits, and the least conscientious one is the indoor shirt dress I3. The most open outfits are fashionable F1, F3, and the least open ones are professional P1, P2, indoor I1, I2, and casual hoodie C3. Personality ratings for each individual outfit are presented in Figure 7a, and ratings of the five types are illustrated in Figure 7b.

4.4. Discussion

The Big Five traits are generally regarded as orthogonal, although previous psychology literature [46] and gesture research [1] reported higher-order factors and substructure of the five personality traits and explained their cause as genetics and neurobiological substrates [47,48]. In particularly, with the same goal of generating virtual characters with desired personality profiles, Ref. [1] found that motion adjustments in gestures could only impact personalities in a 2D subspace rather than five: “plasticity”, which includes extraversion and openness, and “stability”, which includes EMS, agreeableness, and conscientiousness. Through principal component analysis (PCA), they reported that the two principal components (PCs) were sufficient to explain about 75% variance of the personality ratings. Although the personality impact from motion adjustment is mostly restricted in the 2D subspace, the authors suggested other modalities that convey preference and

![Figure 7. Personality ratings for Experiment 3. (a) Ratings for 15 individual outfits. From left to right are P1 ∼ P3, C1 ∼ C3, F1 ∼ F3, O1 ∼ C3 and I1 ∼ I3, in order. (b) Ratings for five outfit types.](image-url)
identity claims, such as clothing choice, may help influence personalities in a finer and more independent way.

To better understand the manifold personality impacts from outfit manipulation, we conducted PCA on the Big Five ratings of the three outfit experiments. The Kaiser–Guttman criterion [49] indicates three components for the outfit type experiment and two components for the outfit color and design experiments, with eigenvalue 1 as the threshold. By inspecting the scree plot and to match the ~75% explained variance used in [1], three PCs are retained for all three experiments, which better explain the substructure of personality ratings. The PCs were subjected to varimax rotation, and the loadings presented in Table 5 are very similar across the three experiments. Thus, different from the 2D personality subspace identified in [1], our experiments indicate that, separate from EMS and conscientiousness traits, agreeableness could be influenced more independently by outfit manipulation than by motion adjustment. Stated differently, outfit manipulation offers finer-grained personality influence compared to motion adjustment.

Table 5. Similar principal components in all three experiments, with explained variance presented in parentheses.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Experiment 1—Color (75.813%)</th>
<th>Experiment 2—Design (73.11%)</th>
<th>Experiment 3—Type (83.265%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PC1</td>
<td>PC2</td>
<td>PC3</td>
</tr>
<tr>
<td>Extraversion</td>
<td>0.756</td>
<td>0.758</td>
<td>0.841</td>
</tr>
<tr>
<td>Openness</td>
<td>0.767</td>
<td>0.887</td>
<td>0.678</td>
</tr>
<tr>
<td>EMS</td>
<td>0.878</td>
<td>0.636</td>
<td>0.977</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
</tr>
</tbody>
</table>

5. Guidelines and Verification

5.1. Guidelines

Based on the experiment results, we propose guidelines for creating virtual characters with particular personalities.

**Extraversion:** To generate characters with high extraversion, designers can prioritize selecting fashionable outfits and design their outfits in warm, highly-saturated, bright colors, with low necklines and high waists, and without sleeves. On the contrary, for virtual characters to look more introverted, they can wear black or dark, low-saturated colored professional or indoor outfits with regular waist lengths, turtlenecks, and long sleeves.

**EMS:** To increase a virtual character’s perceived emotional stability, designers can select professional outfits in low-saturated, dark, cool colors, or in pure white or black, with round neck or high turtleneck and long-sleeve designs. To be perceived as more neurotic and less stable, virtual characters can wear a fashionable low neckline and sleeveless designs in highly-saturated, warm colors.

**Agreeableness:** To make characters look more agreeable, they can wear casual outfits in warm, low-saturated colors, preferably having a round or a high turtleneck, a regular waist length, and short sleeves. Contrarily, to create less agreeable characters, professional or fashionable outfits can be selected. The outfits can be designed in black or cool colors with a shirt collar, a high waist, and no sleeves.

**Conscientiousness:** To increase the perceived conscientiousness, virtual characters can wear professional outfits in black or low-saturated, dark colors, with a regular waist length and long sleeves, avoiding U-neck designs. To make characters less conscientious, their outfits can be designed as indoor clothing, in highly saturated bright colors, with low necklines, high waists, and no sleeves.

**Openness:** To make virtual characters look more open, they can be designed to wear fashionable outfits in saturated colors, with low necklines, high waists, and a sleeveless design. On the contrary, for characters to be perceived as less open, they can wear professional or indoor outfits, preferably in low-saturated, dark colors, with a round or turtleneck or a shirt collar, in regular waist length, and with long sleeves.
5.2. Verification

To verify the applicability of our findings of virtual outfits discussed in Section 5.1, we further designed and conducted a verification test. The general use cases of virtual characters in games, user interfaces, virtual education, and social interactions are with animations. While the great majority of the outfit factors experimented with in Section 4 lead to significant differences in perceived personality, virtual characters are evaluated based on the rendered images, with a domain gap from virtual characters in animation. To generalize our guidelines to a broader scope of applications, a verification test was conducted using animated virtual avatars in the scenario of social communication, to represent the end users in the metaverse at the demographic level. Design options regarding the outfit factors and parameters were offered to users through the user interface of social media apps [14,15]. The test results confirmed that the significant outfit factors listed in Table 4 consistently carry a strong impact on personality perception for virtual characters in the presence of animations.

5.2.1. Test

For the verification test, we selected outfits that correspond to high and low ratings of each personality trait based on Table 4. Factors in outfit color, design, and type were investigated separately. For color, T-shirts described in Section 4.1 were used. According to Table 4, saturated red R_s was selected as the high extraversion, high openness, low EMS, and low conscientiousness configuration. Black N_b was selected as the high EMS, high conscientiousness, low extraversion, low agreeable, and low openness configuration. Low-saturated pink R_l was selected as the high agreeableness outfit. For design, we selected two outfit designs described in Section 4.2: turtleneck with regular waist and long sleeves TRL was selected as the high EMS, high agreeableness, high conscientiousness, low extraversion, and low openness configuration, and sleeveless U-neck with high waist UHN was selected as the high extraversion, high openness, low EMS, low agreeability, and low conscientiousness configuration. For type, outfits in Section 4.3 were used. Leather jacket F_1 was selected as the high extraversion, high openness, low EMS, and low agreeableness configuration. Black suit P_2 was selected as the high EMS, high conscientiousness, low extraversion, and low openness configuration. Indoor cardigan I_1 was selected as the high agreeableness and low conscientiousness configuration. Detailed outfit selections are listed in Table 6. Note that each selected outfit was worn by characters of both genders. We denote high configuration of outfit for each personality trait as O_1 and low configuration of the personality trait as O_0, and leave the superscript to indicate gender. Thus, for the verification test, we have 16 characters, 8 in each of two genders wearing outfits \{R_s, N_b, R_l, UHN, TRL, F_1, P_2, I_1\}.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Extraversion</th>
<th>EMS</th>
<th>Agreeableness</th>
<th>Conscientiousness</th>
<th>Openness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High O_1</td>
<td>Low O_0</td>
<td>High O_1</td>
<td>Low O_0</td>
<td>High O_1</td>
</tr>
<tr>
<td>Outfit Color</td>
<td>R_s</td>
<td>N_b</td>
<td>R_s</td>
<td>N_b</td>
<td>R_l</td>
</tr>
<tr>
<td>Outfit Design</td>
<td>UHN</td>
<td>TRL</td>
<td>TRL</td>
<td>UHN</td>
<td>TRL</td>
</tr>
<tr>
<td>Outfit Type</td>
<td>F_1</td>
<td>P_2</td>
<td>P_2</td>
<td>F_1</td>
<td>I_1</td>
</tr>
</tbody>
</table>

For each virtual character in the selected outfit, we compiled a sequence of animations. To simulate the generic and neutral animations in most use cases, we included six balanced Bitmoji Snaps in the animation sequence to reflect multiple aspects of the virtual character: “thumbs up” and “disapproval” expressing positive and negative attitudes; “two-step dance” and “so sleepy” showing energetic and tired sides of the characters; and “water cooler” and “filing nail” for performing two daily activities (illustrated in Figure 8). Each snap is around 7~8 s, which makes the compiled animation sequence approximately 47 s long (please see the Supplementary Materials Video S1 for more details). Snaps were
captured with an iPad in an AR environment, with a gray floor and a white wall as the background. Minor background color variations may occur due to the natural lighting changes in the room. There were no color variations for the outfits or for all the other virtual content. For each animation sequence, the video resolution is 720 × 1280 pixels, where the virtual character stays animated in the (160, 520) × (200, 800) region of the screen. A total of 16 videos were made, one for each virtual character in the selected outfit. As facial features and facial animations are not the focus of our work, we blurred the face area for all the videos.

Figure 8. Six animations used in the verification test. From left to right, they are: “thumbs up”, “disapproval”, “two-step dance”, “so sleepy”, “water cooler”, and “filing nail”, shown with a female character in the fashionable outfit F_1. Please see the Supplementary Video for more details.

We recruited 27 subjects (21 M, 6 F) in the same way as described in Section 4 to participate in the verification test. They were shown each video and then asked to rate the virtual character’s five personality traits using the TIPI questionnaire on a 7-point Likert scale. Subjects were allowed to replay the clips as many times as they wanted. We hypothesized that high configurations of outfits would yield significantly stronger perceptions of the personality trait, in the presence of generic animations.

5.2.2. Results

Based on the subjects’ ratings, for each personality trait between the high O^f_1, O^m_1 and low O^f_0, O^m_0 configurations, we ran a two-way ANOVA test to verify the effects and interactions of gender and outfit configurations. Detailed results are reported in Table 7 and illustrated in Figure 9. In general, high configuration outfits O_1 do receive higher ratings for the evaluated personality trait compared to low configuration outfits O_0; however, not all of them led to significant differences. High configurations in outfit color significantly increase virtual characters’ perceived extraversion and EMS levels. High configurations in outfit design lead to significantly higher EMS, conscientiousness, and openness ratings. High configurations in outfit type significantly impact perceived extraversion, conscientiousness, and openness. In particular, there is no significant impact found on virtual characters’ perceived agreeableness among varying configurations of all three outfit colors, designs, and type factors in this verification. Compared to the major significant results in Table 4, the diminished significance in this verification could be due to the extra information subjects drew from the neutral animations when making personality judgments, as in the previous experiments, personality cues were solely from static renderings. Although outfits’ impacts are diluted, the significant results in the verification test still confirm the influence of outfit color, design, and type on virtual characters’ perceived personalities in the presence of animations and suggest the general applicability of our outfit guidelines in the use case of animated characters. From another perspective, the results also reflect the important role that animation plays in virtual characters’ personality perception. No significant gender effects and interactions were found in the verification test, which is consistent with previous experiments.
Table 7. Results of verification test, with significant impacts highlighted in bold.

<table>
<thead>
<tr>
<th>Effects</th>
<th>Extraversion</th>
<th>EMS</th>
<th>Agreeableness</th>
<th>Conscientiousness</th>
<th>Openness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>F = 6.817</td>
<td>F = 4.371</td>
<td>F = 1.18</td>
<td>F = 0.968</td>
<td>F = 0.733</td>
</tr>
<tr>
<td></td>
<td>p = 0.01</td>
<td>p = 0.039</td>
<td>p = 0.28</td>
<td>p = 0.327</td>
<td>p = 0.394</td>
</tr>
<tr>
<td>gender</td>
<td>F = 0.58</td>
<td>F = 0.754</td>
<td>F = 0.053</td>
<td>F = 0.029</td>
<td>F = 1.472</td>
</tr>
<tr>
<td></td>
<td>p = 0.448</td>
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Figure 9. Personality ratings of high and low configurations in outfit color, design, and type factors among male and female characters in the presence of generic animations.

6. Conclusions

Understanding how outfit variations are associated with personality perception is a key component in creating diverse and believable virtual characters. This work focused on evaluating the effect of three main outfit factors, i.e., color, design, and type, on a character’s perceived personality through a series of experiments. The significant results reported here provide fundamental insights into how color hue, saturation, and value; design of neckline, waistline, and sleeves; and outfit types of professional, casual, fashionable, outdoor, and indoor influence virtual characters’ perceived personalities. We summarized general guidelines for character designers aiming to create avatars with specific personality profiles. Our verification test confirmed that the outfit guidelines are largely valid for virtual characters in the presence of animations. While the study was designed thoughtfully to reduce the fatigue effect, due to the large amount of stimuli, we acknowledge that participant fatigue could potentially impact the results. To overcome this limitation, we will further investigate better approaches to minimize the fatigue effect in future work. With the emergence of neural radiance fields (NeRF), it is possible to procedurally generate digital humans. In the
future, it would be interesting to further research how to integrate outfit guidelines into human asset generation pipelines.

Although we evaluated many outfit parameters in this work, outfit perception research is by no means complete. In the future, it will be worthwhile to investigate the effect of outfit patterns, prints, and logos on virtual characters’ perceived personalities. Using physically based rendering (PBR), outfits’ fabrics and hygiene conditions can be well visualized to reflect avatars’ specific characteristics. It is also worth investigating how outfits’ body fit, which is commonly implemented through mesh deformation algorithms in industry, conveys characters’ personalities.

As the findings in this work indicate, visual appearance could carry larger and finer-grained impacts relative to body movement on characters’ perceived personalities. In addition to outfits, virtual characters’ visual appearance includes body shape, facial features and expressions, facial hair and hair styles, etc., and each could be an interesting research topic. Accessories such as hats, glasses, and jewelry may also provide significant personality information and need to be further explored.

We hope that our work can provide general guidelines for designing outfits for virtual characters, and we encourage more research in this direction.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/virtualworlds3010002/s1, Video S1: Evaluating the Effect of Outfit on Personality Perception in Virtual Characters.

Author Contributions: Conceptualization, Y.W. and Y.C.; methodology, Y.W. and Y.C.; software, Y.W. and Y.C.; validation, Y.W. and Y.C.; formal analysis, Y.W. and Y.C.; investigation, Y.W. and Y.C.; resources, Y.W. and Y.C.; data curation, Y.W. and Y.C.; writing—original draft preparation, Y.W. and Y.C.; writing—review and editing, Y.W. and Y.C.; visualization, Y.W. and Y.C.; supervision, Y.W.; project administration, Y.W.; funding acquisition, Y.W. All authors have read and agreed to the published version of the manuscript.

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References


41. Takala, M. Studies of Psychomotor Personality Tests; Suomalainen Tiedeakatemia: Helsinki, Finland, 1953; Volume 1.


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